A new technique for the study of periapical bone lesions: ultrasound real time imaging

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Abstract

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Aim This study describes the use of a real time-ultrasound imaging technique (echography) for the study of periradicular lesions.

Methodology Twelve patients with periapical lesions of endodontic origin, diagnosed with conventional clinical and radiographic examination, were examined further using echography at the site of the diagnosed lesions. Each lesion was echographically characterized and described by an expert echographist together with an endodontist. Once the major echographic features were identified, information on the size of the lesion, its content, and its vascular supply was obtained and recorded. A tentative differential diagnosis between a cyst and a granuloma was made based on the data.

Results In all cases it was possible to obtain an echographic image. It was also possible to measure the lesions, to evaluate their content and to view their vascularization in different regions of the mouth.

Conclusions Ultrasound real time imaging is a promising diagnostic technique in endodontology, but further work is required to refine the process.

Keywords: diagnosis, echography, endodontics, periapical lesions.

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Introduction

Radiographs are an important part of root canal treatment, especially for the detection, treatment and follow up of periapical bone lesions. However, routine radiographic procedures do not demonstrate reliably the presence of every lesion (Bender & Seltzer 1961, van der Stelt 1985), and they do not show the real size of a lesion and its spatial relationship with anatomical structures. Furthermore, interrater and intrarater variability can influence diagnosis (Goldman *et al.* 1972, Saunders *et al.* 2000).

In histopathological terms, apical periodontitis can be divided into periapical granulomas and periapical cysts; however, clinical examination and radiographs alone cannot differentiate between cystic and non-cystic lesions (Nair 1998). Being able to distinguish between the two may be of importance in predicting treatment failure (Nair 1998).

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In order to overcome some of these existing shortcomings, it is important that new imaging techniques are evaluated for their ability to diagnose periapical lesions.

Recent findings have shown that direct digital radiography, even when used with imaging processing and colour coding, is no better than conventional radiography in the detection and measurement of periapical lesions (Scarfe *et al.* 1999).

The use of computerized tomography (CT) has been shown to be of help in the management of extensive periapical lesions (Cotti *et al.* 1999) and it has been suggested that CT is a non-invasive method that could be used to make a differential diagnosis between a cyst and a granuloma (Trope *et al.* 1989). Unfortunately, routine use of CT is associated with high dosage of radiation, even though dose reduction methods have been established (Dula *et al.* 1996).

Echography is a real time ultrasound imaging technique that is of great use in numerous diagnostic fields of medicine (Auer & Van Velthoven 1990). The echographic

method, or 'real time echotomography', is based on the reflection of ultrasound (US) waves (echos). US waves are generated by a quartz or synthetic ceramic crystal when it is exposed to an alternating current of 3–10 Mhz. As a result of the piezoelectric effect, the crystal distributes US waves oscillating at the same frequency. The US waves arriving in biological tissues encounter areas of different density and different mechanical and acoustic properties. At the interface between two tissues with different acoustic impedance the US waves undergo refraction and reflection. The echo is the part of the US wave reflected back toward the crystal. The echo is transformed by the crystal into electrical energy, which in turn is transformed into a light spot using a grey scale into a TV monitor. The point of origin of the echo along the line of the US wave is calculated by the computer built into the US apparatus from the time delay between the initiation of the wave signal and its return.

The US image seen on the monitor is produced by automatic movement of the crystal over the tissue of interest. As each movement gives one image of this tissue (depending on its plane) and there is a frequency of 30–50 images per s, they appear in a screen as moving images. Moving the US probe by hand over the area of interest changes the sector plane and thus a real time three-dimensional impression of the space is obtained.

The interpretation of grey values on an image is based on a qualitative comparison of the echo intensity with that of normal tissue. 'Hypoechoic' or 'transonic' is an area with low echo intensity; 'anechoic' is an area where no reflection occurs (i.e. any area filled with fluids), and 'hyperechoic' is an area which has high echo intensity. Bone exhibits a phenomenon of total reflection (hyperechoic/totally echogenic), therefore US imaging can only be performed through windows in bone or where the bony architecture has been altered (Auer & Van Velthoven 1990). Areas which have different types of tissues show what is termed a 'dishomogeneous echo'.

Using 'Colour Power Doppler Ultrasound' it may be possible to evaluate and determine the presence and direction of blood flow within the ecographic image of the tissue, together with information concerning flow velocity and perfusion of the area. Power Doppler will give a colour coded representation of the intensity of Doppler signal and its modification with time (Fleischer & Emerson 1993).

The echographic examination of bone lesions of endodontic origin has not been reported to date. The purpose of this study was to use ultrasonic imaging as a diagnostic aid for the management of extensive periapical lesions.

Materials and methods

Echographic examination

An Elegra Siemens Apparatus with a regular-size, linear, high definition, multi frequency ultrasound probe (Siemens, Erlangen, Germany) was used at a frequency of 7–9 Mhz. Twelve white patients, aged between 25 and 50 years, were selected for the study. The patients had been diagnosed with periradicular lesions of endodontic origin based on clinical signs and symptoms (Trope & Sigurdsson 1998) and intraoral and panoramic radiographic findings. The patients were scheduled to be treated in the Department of Conservative Dentistry and Endodontics at the University Clinic, Cagliari. Patients who agreed to take part in the study were asked to sign an informed consent form before undergoing the echographic examination.

The area of interest within the mouth was selected for the echography. The ultrasonic probe was covered with an insulating latex finger from a glove. The probe was then positioned on the buccal sulcus corresponding to the apical area of the tooth. Subsequently, it was placed outside the mouth against the skin at the external area in order to assess which technique gave the best results. Once the probe was in contact with the tissue, it was then moved in order to obtain an adequate number of transversal scans to define the bony defect.

The saved echographic images (magneto-optical disk, Eastman Kodak, Rochester, NY, USA) were analysed and discussed by an expert echographist, together with an endodontist and an oral surgeon. The lesions were first identified in the echotomograms, based on semeiotic echographic principles of bone pathosis; then a comparison was made with the radiographic images of the same lesions. A descriptive chart was subsequently made for every case. In the chart there was (i) one section dedicated to general information on the patient; (ii) a second section describing the lesion of interest as it appeared in the radiograph/s (iii) a third section which described the lesion as seen in the echography.

Results

No discomfort was experienced by patients when the examination was performed using the probe, either internally or externally. Images of the periradicular lesions were obtained and identified in all the cases using both the intraoral and extra-oral technique. Based on the descriptive chart, the radiographic images were able to describe the lesions and their relationship with anatomical landmarks

Figure 1 Panoramic radiograph with a lesion involving the periradicular area of teeth 32, 33 and 34 (arrowed).

Figure 2 Echotomogram (ultrasound image) of the lesion in Fig. 1, showing a 'transonic lesion' (arrowed) with well defined and reinforced contours (arrowed).

in two dimensions, but did not provide information as to their size and content. The echotomograms showed the lesion within the bone in three dimensions, and their content in terms of fluids or tissue and blood vessels (at colour/power Doppler). In the echotomograms it was also possible to obtain a precise measure of the diameters of the lesions, whilst it was not possible to constantly identify any anatomical reference points (i.e. specific teeth).

The echographic study showed the presence of six lesions which were frankly transonic (hypoechoic) and therefore could be interpreted as cavities filled with fluids. These cavities had well defined contours and no evidence of vascularization at the colour-power/Doppler control (Figs 1, 2). The remaining six lesions exhibited a rounded shape only partially defined. In two of the cases an interruption of the bone profile was observed mesially; the echostructure of these lesions showed a content which was in part hypoechoic and in part corpuscolated (Figs 3, 4).

The content of the other four lesions was frankly echogenic (hyperechoic); (Figs 5, 6). With colour-power-Doppler examination all these six lesions showed a rich vascularization (Figs 4, 6).

Discussion

The results of this study demonstrated that echographic examination is a real-time imaging technique that has the potential to be used in the assessment of periradicular lesions of endodontic origin.

The energy of US waves is absorbed in the form of heat energy, and direct transfer of the mechanical energy of sound waves into tissue is potentially dangerous because it causes cavitation and vibration (Auer & Van Velthoven 1990). These phenomena depend on the time of application of the sound energy. During US imaging the energy developed is low (max 50 mW cm2^{-1}) and the time of application short. Only during 0.1% of total activity is the crystal emitting energy; for the remaining 99.9% of the time it is 'listening' (receiving echos). In experimental and clinical studies no adverse effects of ultrasound waves have been reported (Baker & Dalrymple 1978, Fleischer & Emerson 1993). The effect of repeated investigations is less certain, but even so, the risks

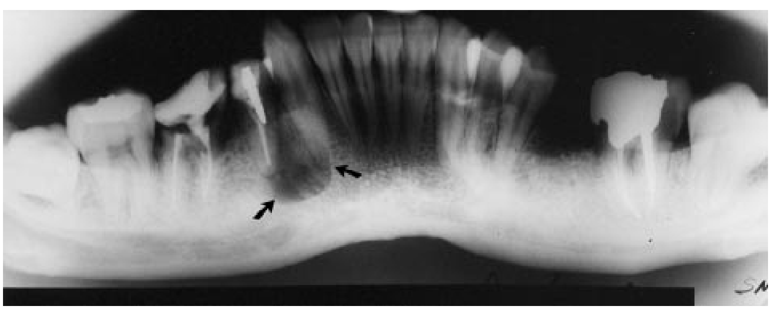

Figure 3 Panoramic radiograph with a lesion (arrowed) in the periradicular area corresponding to tooth 44 (fractured root).

Figure 4 Echotomogram (ultrasound image) of the lesion in Fig. 3 (framed) with partially transonic (fluid filled) content (arrowed) and partially corpuscolated with rich vascularization (coloured).

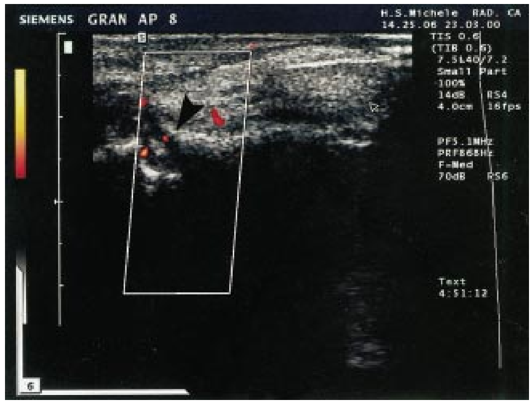

Figure 6 Echotomogram (ultrasound image) of the same lesion in Fig. 5 (framed): an echogenic content, partially defined contours (arrowed), and an intralesion vascular supply (coloured) are visible.

entailed by radiographic investigations are much greater (Liebeskind *et al.* 1981, Martin 1984).

A major concern over the performance of ecography was the difficulty in attributing the lesions to a specific area of the maxillary bone (once the exam had been printed) because the dental landmarks (i.e. roots) were not specifically visualized. This made it difficult to orient the lesion in the different regions of the mouth, without using a reference radiograph. In addition, in order to enhance patient comfort and to improve the manipulation of the probe, a high quality, small ultrasound probe should be manufactured for endodontic use.

Conclusions

The initial findings from this study suggest that echography is an easy and reproducible technique that has the potential to supplement conventional radiography in the diagnosis and follow-up of extensive periapical lesions. It provides specific information on the size of the lesion and has a low radiation risk. Furthermore, its potential to describe the contents of the lesions (i.e. watery versus corpuscolated) and their vascularization may become an important factor when making a differential diagnosis between lesions of endodontic origin (i.e. granulomas versus cysts) and also between other lesions of the maxillary bones. More studies are currently being carried out.

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Figure 5 Panoramic radiograph with a lesion (arrowed) in the periradicular area corresponding to tooth 45.

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